effects of these floods were felt in the Missouri River early in June, and more or less overflow occurred between Yankton, S. Dak., and the mouth of the Niobrara River. Considerable damage was done to hay and pasture lands in this section while in the Black Hills region the losses amounted to about $500,000. Warnings to remove stock and portable property were issued in ample time.

Nothing of special interest occurred along the Mississippi River. The lower river remained quite high at stages a few feet below the flood stage, a rise from the Ohio and upper Mississippi rivers coming down before the flood waters of the previous month had passed out. In the Vicksburg, Miss., district crops to the value of $150,000 and other property to the value of $10,000 were destroyed.

The upper Mississippi River was slightly above the flood stage in the vicinity of Hannibal, Mo., on the 12th and 13th on account of heavy rains above, and was again rising rapidly at the end of the month under the influence of heavy rains and a decided rise over the watershed of the Des Moines River. The Illinois River was above the flood stage during much of the time, but there was no resulting damage of consequence.

Excellent boating stages prevailed along the Ohio River.

The heavy rains of the 2d and 3d over the South Atlantic States caused general floods in the rivers of the Carolinas, and warnings were issued on those days. Livestock, etc., to the value of about $75,000 were saved, and crops to the value of about $25,000 were destroyed. The floods in the Tombigbee River and the rivers of central and southeastern Mississippi about the same time were noted in the MONTHLY WEATHER REVIEW for May, 1909.

The freshets in the Grand, the Colorado, the upper Arkansas, and the Rio Grande were fully covered by special warnings issued while the unmelted snows still covered the mountain slopes. The freshets were due to the melting snows, and the fluctuations, the greatest in many years, followed closely the changes in temperature.

The annual rise in the Columbia River reached its maximum at Portland, Oreg., on the Willamette River, on the 21st with a crest stage of 21.6 feet, 6.6 feet above the flood stage. A report on this rise will be made later.

The Sacramento River remained at moderate stages, while the San Joaquin was generally above flood stage, though only moderately so, and without unusual incident.

The highest and lowest water, mean stage, and monthly range at 215 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

ANNUAL RISE OF THE COLUMBIA RIVER, 1909.

By E. A. BEALS, District Forecaster, Portland, Oreg.

The two principal features to be considered in connection with the annual rise of the Columbia River are the amount of snow in the mountains within the drainage area of that stream at the close of the cold season and the subsequent temperatures in relation to their effect upon the melting of this snow. Summer thundershowers also affect the behavior of the rise, but their importance is insignificant as compared with the other two factors. Reports received at the end of March from Weather Bureau sources showed that the snowfall at the headwaters of the Snake River was unusually heavy and well packed, and reports from the Canadian Meteorological Service and from the Weather Bureau showed the snowfall at the headwaters of the Columbia River to be heavier than last year and in some places to be above the average for a number of years. During the spring months the newspapers published, from time to time, items stating that the snow was very heavy in the mountains within the drainage area of the Columbia River.

The temperature and precipitation data for the northern Plateau as published in the MONTHLY WEATHER REVIEW reflect fairly well the conditions prevailing at higher elevations in the same localities, and as this district is largely within the Columbia River Basin, a table showing these data follows:

TABLE 1.—*Temperature and precipitation of the northern Plateau during the cold season, 1908–9.*

Month.	Temperature.		Precipitation.	
	Mean.	Departure.	Average.	Departure.
1908.	°	°	*Inches.*	*Inches.*
November	42.0	+3.0	0.83	−0.55
December	30.4	−1.8	0.80	−0.90
1909.				
January	29.0	+0.3	2.72	+1.10
February	37.7	+5.6	1.90	+0.50
March	43.2	+3.0	1.01	−0.60
	36.5	+2.0	7.26	−0.45

The northern Plateau precipitation, as will be seen by the foregoing table, was 0.45 of an inch below normal and the temperature was 2° above normal. The precipitation was heavier than usual in January and February and below normal during the other months when the precipitation was likely to be mostly in the form of snow. The backward spring kept the snow from melting in the mountains until very late in the season.

The reports of heavy snow in the mountains combined with the backwardness of the spring caused the people affected by the annual rise of the Columbia River to become unduly alarmed, and many irresponsible people made predictions that the rise this year would exceed that of all former years. Telegraphing of river reports to this office began on March 1 and they were continued until the latter part of June from nearly all the stations and from a few of the most important stations till the end of July.

The river did not begin to show any material rise until the third decade in June, but it was necessary to have the reports telegraphed in order to allay the alarm of the people living in the flooded areas, and who were expecting a big rise on account of the alarming reports that had been disseminated by the newspapers.

During the entire rise accurate forecasts of the height that the water would reach were issued from this office covering periods of from four to six days in advance of their appearance. At no time did the stage reached fall short of the stage forecast by more than a few tenths of a foot and the forecast for the crest of the flood was only two-tenths of a foot higher than the stage actually reached.

Table 2 shows the crest stages at all the river stations affected by the rise.

It will be noticed on the hydrograph, Fig. 1, that there were two crests at Portland, an unusual occurrence. For the purpose of comparison Table 3 presents the stages of all the recorded flood crests at Portland, Ore., due to the annual rise in the Columbia River.

After the first crest of 20.5 feet was reached on June 10 many people affected by the rise thought that this was the highest stage that would be reached, but all were told that the river might rise again and advised not to place their goods in jeopardy until they were assured that the danger had passed. This advice was well received and when the second rise oc-

curred no losses ensued, in fact no movable property was lost in this city or in the country on account of the flood. The only damage, so far as learned, was to crops where farmers had planted them in the spring on bottom land, taking chances of their being inundated. Losses of this character, however, were smaller than usual, as most of the farmers were expecting a big rise and were prepared for it. The river at Portland was above the flood stage from June 4 to July 17, inclusive, or 44 days in all. Part of this time it was as much as six feet above the flood stage and the utility of the service can not be questioned when it is considered that vast quantities of goods were moved to places of safety without any losses whatever except the extra cost of moving.

TABLE 2.—*Flood crests, Columbia River drainage*, 1909.

Stations.	Height.	Date.
	Feet.	
Weiser, Idaho	12.6	June 7
Lewiston, Idaho	19.0	June 5
Riparia, Wash.	17.8	June 6
Bonners Ferry, Idaho	27.9	June 6
Newport, Wash.	18.6	June 25
Northport, Wash.	32.9	June 23
Wenatchee, Wash.	39.7	June 24
Kennewick, Wash.	19.4	June 20
Umatilla, Oreg.	22.6	June 18
Celilo, Oreg.	19.3	June 20
The Dalles, Oreg.	38.1	June 19
Cascade Locks, Oreg.	30.1	June 20
Vancouver, Wash.	22.0	June 22
Portland, Oreg.	21.4	June 21

TABLE 3.—*Flood crests at Portland, Oreg., during the annual rise of the Columbia River.*

Year.	Stage.	Year.	Stage.
	Feet.		*Feet.*
1879	19.3	1895	16.3
1880	27.3	1896	23.8
1881	19.7	1897	23.7
1882	26.1	1898	20.7
1883	17.8	1899	24.2
1884	20.2	1900	17.8
1885	14.5	1901	20.8
1886	20.0	1902	20.7
1887	25.7	1903	24.0
1888	18.2	1904	20.8
1889	10.0	1905	13.6
1890	20.1	1906	13.4
1891	14.1	1907	19.2
1892	19.3	1908	21.2
1893	22.0	1909	21.4
1894	33.0		

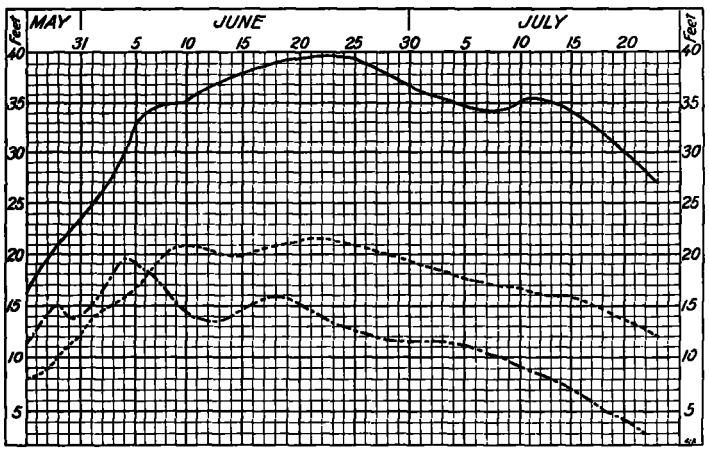

FIG. 1.—Hydrographs of daily stages on the Columbia River system, June and July, 1909.

——— Columbia River at Wenatchee, Wash.
– – – Snake River at Lewiston, Idaho.
– · – · Willamette River at Portland, Oreg.

FROST DAMAGE PREVENTED BY COVERS.

Prof. A. G. McADIE. Dated San Francisco, Cal., June 23, 1909.

A recent letter from Eastern Agricultural College, Wye, Kent, England, brings up the question whether it is the heat or the smoke developed by the fires and smudges of frost-fighting apparatus, which prevents the damage by frost in orchards, vineyards, etc.

The great mass of experiments made in California orchards show that direct heating of the air by open fires has not been sufficient to prevent injury at times of very low temperatures. A large amount of the heat thus produced is wasted; the efficiency of the method is low. This is illustrated by the following experience of a gentleman who is a close observer, an earnest student of the problem of frost-protection, and one in whom I have the greatest confidence. During the night of December 20–21, 1908, on a certain California ranch, the temperature for fourteen hours ranged between 19° and 24° F. For thirty-six hours the temperature did not rise above 28°. During this night the gentleman referred to burned 15 cords of wood and about 40 tons of wet hay in his efforts to protect his orchard. The relative humidity was low, there was little movement of the air, and he reports that "the smoke rose as straight as a pine tree." At the intersection of two roads in the orchard a large fire was maintained, and 30 feet distant the temperature in an olive tree was observed. Another fire was burning within 20 feet of this tree on a second side, and on yet a third side was a third fire maintained within 25 feet of the same tree. The temperature at the tree, however, remained at about 20° F. from 3 to 8 a.m. of December 21. This was the coldest weather in this locality since 1888. It is evident that in this case a large amount of heat escaped without producing the desired warming effect, i. e., was lost, wasted. It is, of course, well known that the rate of conduction of heat through air is low.

Other evidence has led me to the conclusion that open fires of coal, oil, etc., in wire baskets, in pots, on the ground, or indeed any source of heat will not, unaided, serve to protect plants under *severe* conditions. The oil pot is objectionable both because of its low efficiency and because the soot from it may settle on the fruit. The briquette has similar drawbacks and also is troublesome to ignite. The small sheet-iron stove is more satisfactory and the heat radiated by it is not lost to the same degree that it is from other devices. It has the additional advantage that it warms the air near the ground whence by a step-to-step process the heat is conducted to the higher strata, i. e., those 10 to 16 feet above the ground, thus affording protection to the branches of the deciduous fruit trees also.

The ideal method of frost protection is a combination of a cover device and a heating device. The cover, properly placed, prevents the excessive loss of heat from the soil, plants, and objects beneath it, and it may be stated that the heat energy involved is much greater than that given for the same area by a number of brisk fires burning for hours. By conserving the earth's heat we employ the very cheapest heat energy that can be obtained, notwithstanding the initial expense of the cover. A proper cover is, in my opinion, the most effective means of protection against injury to plants from low temperatures. Furthermore, the locations most subject to frost are the low points, vales, hollows, and depressions. Elevated valleys shut in by hills are especially bad. We now clearly recognize that the conditions of *air drainage* must be studied for any given locality. Many investigations could be quoted proving the correlation of low temperatures with the low levels. Consequently a cover spread some feet above the surface where there is a particularly frosty spot would by its mechanical interference with the flow of the air, as well as by obstructing the radiation of heat, prevent injury by frost.

It is my opinion that those who claim that "heat and not